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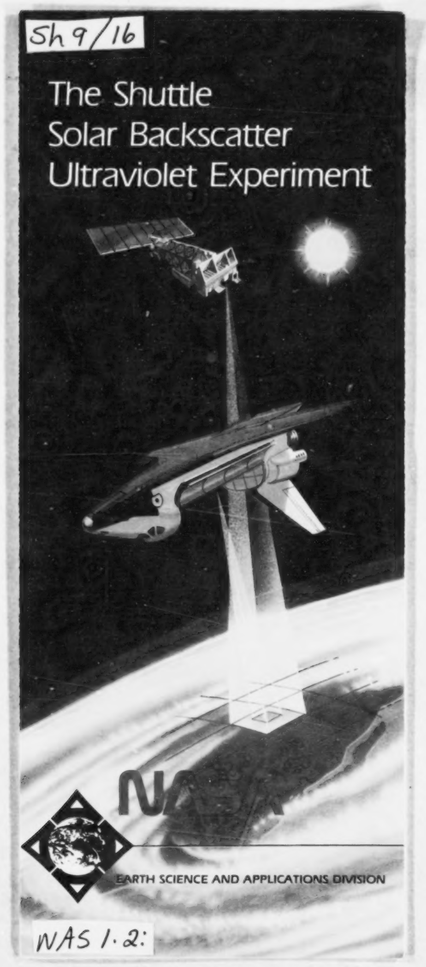

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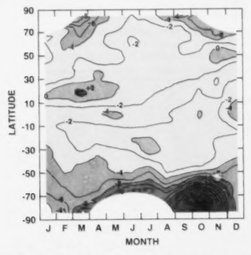
An Issue of Global Ozone Change. . .

Ozone depletion in the upper atmosphere is an issue of increasing concern:

- In 1985, the British Antarctic Survey announced the discovery of an ozone 'hole' over Antarctica during the austral springtime. As of 1987, seasonal depletion was as high as 60 percent in some areas over Antarctica.
- In March 1988, the NASA-led Ozone Trends Panel reported that since 1970, total ozone has decreased by 1.7 to 3 percent over the latitudes covering the United States, Japan, the Soviet Union, and Europe.

Given ozone's role in shielding the Earth from harmful ultraviolet radiation and controlling stratospheric temperature, these findings have worldwide health and environmental implications.

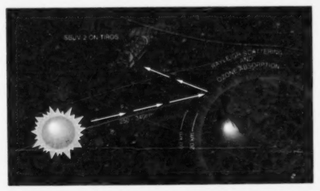
Concern over the thinning of the ozone layer has sparked increased emphasis on developing and improving ozone measurement methods and instruments. Accurate, reliable measurements from space, critical to the detection of predicted ozone trends, also will form a basis for assessment of potential effects and development of corrective measures.



Percentage change in global ozone by month and latitude between 1980 and 1987, as measured by the Total Ozone Mapping Spectrometer (TOMS) and corrected to ground observations of total ozone. The red area at bottom represents the Antarctic ozone "hole."

Measuring Ozone Via the SBUV Instrument. . .

Ozone monitoring efforts of NASA and NOAA rely on space-based **Solar Backscatter Ultraviolet (SBUV)** instruments, which measure the total amount and height distribution of ozone in the upper atmosphere. The original SBUV instrument flew on NASA's Nimbus-4 satellite, demonstrating the effectiveness of the technique. The SBUV instrument aboard NASA's Nimbus-7 satellite provided an 8-year data set that will be continued into the late 1990s by the SBUV/2 aboard NOAA's TIROS satellites.



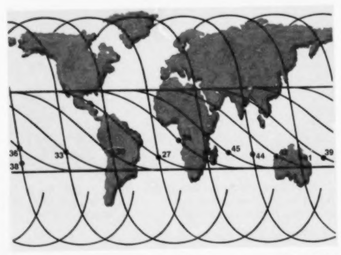
Ozone is derived from the SBUV/2 instrument from the ratio of observed backscattered radiance (IA) to the solar irradiance (FA) in the ultraviolet. This ratio is termed the ultraviolet *albedo*.

The SBUV instrument measures solar irradiance and radiation backscattered from the Earth's atmosphere in 12 discrete wavelength channels in the ultraviolet. Since ozone absorbs radiation in the ultraviolet wavelengths, its amount can be derived from the ratio of backscattered radiation to incident solar radiation. Variations in backscattered radiation indicate the vertical distribution of ozone in the atmosphere.

The SBUV technique has proven to be a reliable method of measuring ozone and solar ultraviolet irradiance. However, problems do exist with calibration drift and instrument degradation over time. The extremely precise measurements required to accurately measure and map global ozone and solar irradiance make the calibration question a critical one.

Solution to SBUV Calibration Drift. . .

To solve data reliability problems resulting from calibration drift, NASA has developed and tested the **Shuttle Solar Backscatter Ultraviolet (SSBUV)** instrument. During regular Shuttle flights, SBUV/2 performance can be assessed by direct comparison of data from both the SSBUV and SBUV/2 instruments viewing nearly the same Earth location. Whereas previous calibration processes have relied solely on ground-based reference standards and instruments, this procedure will permit calibration **in space** supplemented by a rigorous program of laboratory calibration before and after each SSBUV flight.



Selected SSBUV and SBUV/2 orbit coincidences. A coincidence is defined when observations over a given point can be taken by both instruments within 60 minutes. These coincidences will occur 16 times daily over the duration of the experiment. Numbers indicate the interval (in minutes) between satellite observations.

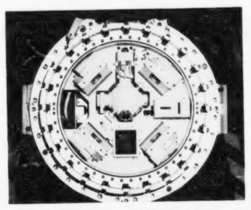
At coincidental orbit points, the SBUV/2 and SSBUV instruments will make correlative measurements of ozone parameters. SSBUV data will be used to assess the degree of calibration drift in the SBUV/2 instrument. Based on these data, and on ground-based measurements, corrections to the SBUV/2 data will be made.

SSBUV measurements will also be compared with measurements from other solar radiation-measuring instruments aboard the Shuttle and the Upper Atmosphere Research Satellite (UARS).

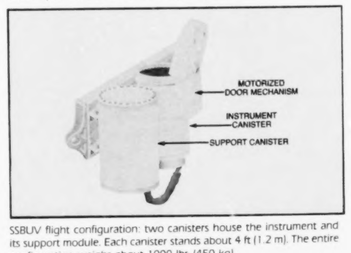
The SSBUV Instrument. . .

Like its SBUV/2 companion, the SSBUV consists of two ¼-meter Ebert-Fastie monochromators arranged consecutively to reject stray light from the spectral field of measurement. At the Goddard Space Flight Center (GSFC) SSBUV facility, features were added to the SBUV/2 prototype instrument to satisfy Shuttle flight requirements:

- A **transmission diffuser** was installed to transmit sunlight to the SSBUV sensor module
- **Solar and nadir aspect sensors** were developed to measure the SSBUV instrument's inclination toward the Sun and Earth during observation periods
- An **in-flight calibration system** was developed and installed to perform SSBUV instrument calibration checks and account for calibration drift



Top view of the SSBUV instrument. The in-flight calibration system is situated in the center, surrounded by solar and nadir aspect sensors. The red plate covers the instrument entrance aperture.



SSBUV flight configuration: two canisters house the instrument and its support module. Each canister stands about 4 ft (1.2 m). The entire configuration weighs about 1000 lbs (450 kg).

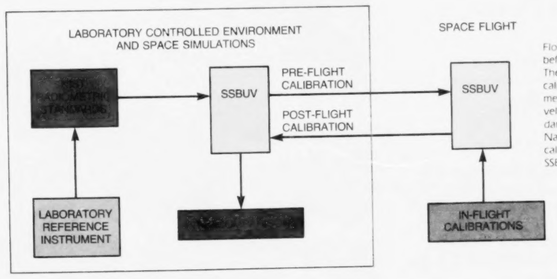
The SSBUV Payload. . .

The need for regular observations aboard the Shuttle required the SSBUV instrument to be designed as largely self-supporting, needing only a few simple Shuttle interfaces. The result is a virtual stand-alone experiment, mountable in various locations within the Shuttle bay.

The SSBUV instrument and its dedicated electronics, power, data, and command systems are mounted into two canisters. The **Instrument Canister** holds the instrument and its specially designed aspect sensors and in-flight calibration system. A Motorized Door Assembly (MDA) opens to allow the SSBUV instrument to view the Sun and Earth, and closes during the in-flight calibration sequence. The MDA also prevents contamination from the orbiter environment.

A flight microprocessor reformats all SSBUV data and provides instrument control during flight. Instrument functions are initially commanded by the Shuttle crew, then sequenced by the microprocessor through about 30 operating modes.

The **Support Canister,** linked to the Instrument Canister by a single cable, contains the power system, data storage, and command decoders. The dedicated power system can operate the SSBUV payload for a total of about 40 hours.



Flow diagram of the SSBUV calibration before, during, and after the SSBUV flight. The process involves pre- and post-flight calibrations against a laboratory instrument and radiometric standards developed by the National Institute of Standards and Technology (NIST, formerly the National Bureau of Standards). On-board calibration checks are conducted by the SSBUV's own calibration system.

Maintaining SSBUV Calibration. . .

The SSBUV experiment consists of a unique program of laboratory and in-orbit calibration. An **in-flight calibration system,** the first of its kind, has been developed by NASA to track SSBUV instrument response from the time it leaves the laboratory until the time it returns. An array of halogen, deuterium, and mercury lamps provides a stable UV light source, and performs on-board wavelength and radiometric calibration checks. These lamps are activated by command of the Mission Specialist.

A special Calibration Facility has been set up at GSFC to develop and test the SSBUV instrument and maintain a state-of-the-art calibration capability (see flow diagram below). This facility contains all the necessary test equipment to perform accurate and precise calibrations of the instrument for the duration of the experiment. A refurbished Nimbus-7 SBUV Engineering Model will be used as a laboratory reference instrument by tracking the radiometric standards and calibration of the flight instrument. Laboratory intercomparisons will be performed with other solar-ultraviolet radiation-measuring instruments to be flown on the Shuttle and UARS.

Mission Requirements. . .

The first SSBUV flight will occur in late 1989, with regular flights scheduled throughout the 1990s. Mission requirements with respect to data collection are:

- Shuttle flights every 8-12 months coincident with NOAA SBUV/2 instrument operation until 1996
- Solar view data at least twice per Shuttle mission
- Earth view data of sufficient duration to compare with SBUV/2. This translates to 32 coincident measurements with SSBUV and SBUV/2 instruments, equivalent to about 16 hours of Earth observations

SSBUV Benefits and Applications. . .

Implementation of the SSBUV program represents a major step forward in our ability to enhance the reliability and integrity of the long-term environmental data sets obtained through space-based remote-sensing instruments. Regular observations by the SSBUV instrument on board the Shuttle also will:

- Provide more accurate, reliable readings of global ozone, resulting in better determination of trends and a surer basis for protective actions
- Enable the development of improved models of ozone dynamics, allowing a better understanding of ozone change and its causes
- Serve as an impetus to the development of space-based approaches to preventing or mitigating the effects of instrument degradation

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For more information on the SSBUV program, contact:
Ernest Hilsenrath, SSBUV Principal Investigator,
Goddard Space Flight Center, Greenbelt, Maryland 20771,
or
Robert Watson, Chief, Upper Atmosphere Research
Program, NASA Headquarters, Washington, D.C. 20546